

A06 — Furnace and flue gas (furnace draft)

FMU model and guide for PLC programming

Version 1.0

Student exercise — Homa Virtual Plant (Model-in-the-Loop)

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Contents

1. Exercise objective.....	3
2. Process description (what the model represents).....	3
3. FMU interface — signals.....	3
3.1. FMU inputs.....	3
3.2. FMU outputs (measurements the PLC reads).....	3
4. What the PLC must achieve (control objectives).....	4
5. Suggested control structure (guideline).....	4
6. Recommended sample times.....	4
7. Test scenarios and acceptance criteria.....	4
8. Integration into Homa Virtual Plant.....	5
9. Notes on the model.....	5

1. Exercise objective

You are given an **FMU model** representing a furnace with temperature, O₂ and draft control. Your task is, through **Homa Virtual Plant** to connect a PLC to this model and write a **PLC program that controls the process** according to the given objectives.

This is a **Model-in-the-Loop (MIL)** setup: the model mimics a real plant, your PLC drives it, and you develop and test your program on a virtual system. The model is “open” — it contains no controller of its own; **all control is performed by your PLC** through the model inputs.

2. Process description (what the model represents)

The furnace burns fuel with primary and secondary air; the ID fan maintains a negative pressure (draft). The PLC controls the temperature (fuel), O₂ (air) and furnace pressure (ID fan). Load is a disturbance.

Available / in the process:

- u_fuel_cmd: fuel (temperature / power).
- u_primary_air_cmd / u_secondary_air_cmd: air (O₂, combustion).
- u_id_fan_cmd: ID fan (draft / furnace pressure).

3. FMU interface — signals

This is the most important part. Pay attention to the signal direction:

Signal direction: what is an **INPUT** for the FMU is an **OUTPUT** (command) for your PLC, and vice versa. The actuators your PLC **writes**; the measurements your PLC **reads**.

3.1. FMU inputs

a) Actuators — controlled by your PLC (PLC outputs):

Variable (FMU)	Type	Unit	Range	Description
u_fuel_cmd	Real	–	0.0 – 1.0	Fuel
u_primary_air_cmd	Real	–	0.0 – 1.0	Primary air
u_secondary_air_cmd	Real	–	0.0 – 1.0	Secondary air
u_id_fan_cmd	Real	–	0.0 – 1.0	ID fan (draft)

b) Disturbances / scenario — the environment, NOT controlled by your PLC:

Variable (FMU)	Type	Unit	Range	Description
u_load_disturbance	Real	–	0.0 – 1.0	Load disturbance

You set the disturbances on the **PLC HMI** (as a parameter / simulated sensor), and the PLC forwards them to the FMU. They are not an output of your controller.

3.2. FMU outputs (measurements the PLC reads)

Variable (FMU)	Type	Unit	Range	Description
y_furnace_temperature	Real	°C	~600 – 1150	Furnace temperature
y_oxygen	Real	vol-%	0 – 18	Oxygen
y_furnace_pressure	Real	Pa	~ -50 – 50	Furnace pressure (draft)
y_flue_gas_flow	Real	kg/s	0 – ...	Flue-gas flow
y_heat_release	Real	MW	0 – ~30	Released heat

4. What the PLC must achieve (control objectives)

Your PLC program must:

1. Control the temperature (y_furnace_temperature) via fuel.
2. Trim O₂ (y_oxygen) via air.
3. Maintain the draft/pressure (y_furnace_pressure) via the ID fan.
4. Permissives (purge/flame) and trip on exceedance.

The objectives are given; **you design the control method yourself** (a suggested structure is provided below as an aid).

5. Suggested control structure (guideline)

Cascade loops:

- Temperature PI (0.5 – 2 s): y_furnace_temperature → u_fuel_cmd.
- O₂ PI: y_oxygen → u_primary_air_cmd (+ secondary).
- Draft PI (100 – 500 ms): y_furnace_pressure → u_id_fan_cmd.

Safety:

- Purge/flame permissives before fuel; trip on high pressure/temperature.

6. Recommended sample times

Layer	Recommended cycle
Draft	100 – 500 ms
Temperature / O ₂	0.5 – 2 s
FMU co-simulation communication step	~0.1 – 1 s

7. Test scenarios and acceptance criteria

Scenario	How to trigger	Expected PLC behaviour	Pass criterion
ID-fan trip	u_id_fan_cmd = 0	pressure rises, response	safe mode
Air loss	air drops	compensation / O ₂	stable
Fuel step	u_fuel_cmd step	T / O ₂ response	stable recovery
Pressure step	draft disturbance	draft PI responds	pressure within the limit
Purge permissive	no purge	fuel blocked	no ignition without purge

General criteria: controlled variables within limits, no instability / excessive cycling, correct response to faults.

8. Integration into Homa Virtual Plant

5. Load `Plant.fmu` (the compiled model) into Homa VP.
6. Map the FMU variables: **actuators** (`u_*`) as PLC outputs, **measurements** (`y_*`) as inputs.
7. Disturbances (`u_load_disturbance`) are set on the HMI as operating conditions and tests; the PLC forwards them to the FMU.
8. Select a communication channel (e.g. OPC UA / S7) and run the closed loop.

The model is configured for **StopTime 600 s** (Interval 1 s). Real-time pacing is driven by Homa VP via a speed factor.

9. Notes on the model

Important: the model is a simplified starter plant for developing and testing PLC logic — **it is not a validated industrial model**. The parameters are illustrative; calibrate them before real use.

- The dynamics are approximate; the purpose is a control exercise, not exact process analysis.